UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
611 RYAN PLAZA DRIVE, SUITE 400
ARLINGTON, TEXAS 76011-8064

October 26, 1999

Stephen M. Quennoz, Trojan Site
Executive and Plant General Manager
Portland General Electric Company
Trojan Nuclear Plant
71760 Columbia River Highway
Rainier, Oregon 97048

SUBJECT: NRC INSPECTION REPORT 50-344/99-07; 72-17/99-05 AND NOTICE OF VIOLATION

Dear Mr. Quennoz:

An NRC inspection was conducted on May 20 thru June 1, June 30 thru July 1, July 10-21, and August 4-5, 1999, at your Trojan Nuclear Plant. The enclosed report presents the scope and results of this inspection. On September 28, 1999, a followup telephonic exit was held between the Inspection Team Leader, the NRC Project Manager for Trojan from the Spent Fuel Project Office, NRC Region IV management, and your staff. During this discussion, additional information was provided by the NRC concerning the violation identified in this report.

The primary purpose of this inspection was to observe dry cask storage activities related to the loading of the first TranStor™ cask. Problems encountered during cask loading, relating to the coating used on the basket, prevented the completion of this activity during the inspection. The basket had been partially loaded with spent fuel at the time cask loading activities were stopped. The spent fuel was removed and placed back into spent fuel pool storage. By a letter dated July 20, 1999, you committed to submit a license amendment request to revise the safety analysis report to reflect the use of the TranStor™ basket with less than 100 percent coating and to address the potential for hydrogen generation in the basket, including an evaluation of hydrogen issue against NRC Bulletin 96-04. In addition, you committed to perform a visual inspection of the basket internals to verify the condition of the basket.

Based on the results of this inspection, the NRC has determined that a violation of NRC requirements occurred related to ISFSI activities. This violation is cited in the enclosed Notice of Violation (Notice) and the circumstances surrounding it are described in detail in the enclosed report. In addition, an unresolved issue was identified related to compliance with applicable industry codes concerning PGE Calculation No. TI-86. This issue is discussed on page 25 of this report. You are requested to evaluate this matter in preparation for a review during a future NRC inspection.

You are required to respond to this letter and should follow the instructions specified in the enclosed Notice when preparing your response. The NRC will use your response, in part, to determine whether further enforcement action is necessary to ensure compliance with regulatory requirements.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosures will be placed in the NRC Public Document Room (PDR).

Should you have any questions concerning this inspection, we will be pleased to discuss them with you.

Sincerely,

/s/

Dwight D. Chamberlain, Director
Division of Nuclear Materials Safety

Docket Nos.: 72-17; 50-344
License Nos.: SNM-2509; NPF-1

Enclosures:
1. Notice of Violation
2. NRC Inspection Report
   50-344/99-07; 72-17/99-05

cc w/enclosures:
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ENCLOSURE 1

NOTICE OF VIOLATION

Portland General Electric Company	Docket Nos.: 50-344; 72-17
Trojan Nuclear Plant	License Nos.: NPF-1; SNM-2509

During an NRC inspection conducted May 20 thru June 1, June 30 thru July 1, July 10-21, and August 4-5, 1999, a violation of NRC requirements was identified. In accordance with the "General Statement of Policy and Procedures for NRC Enforcement Actions," NUREG-1600, the violation is listed below:

> 10 CFR 72.48, "Changes, tests, and experiments," Part 72.48(a)(1) states "The holder of a license issued under this part may: (i) make changes in the ISFSI described in the Safety Analysis Report, (ii) make changes in the procedures described in the Safety Analysis Report, or (iii) conduct tests or experiments not described in the Safety Analysis Report, without prior Commission approval, unless the proposed change, test or experiment involves a change in the license conditions incorporated in the license, an unreviewed safety question, a significant increase in occupational exposure or a significant unreviewed environmental impact.
>
> Contrary to the above, on April 27, 1999, the licensee approved Safety Evaluation 200-1 to allow a PWR basket overpack, as described in the Trojan ISFSI Safety Analysis Report, Section 4.2.4.2.3, to be used for permanent storage of spent nuclear fuel at the Trojan ISFSI. Use of the overpack as a temporary storage device had been accepted by the NRC in Sections 4.3.2.3 and 5.2.2.1 of the NRC safety evaluation for the TranStor™ cask. Safety Evaluation 200-1 did not identify that using the overpack for permanent storage was different than described in the NRC safety evaluation and would require a change to Technical Specifications (TS) 3.1.1 "PWR Basket Shield Lid Weld Helium Leak Rate," TS 3.1.2 "PWR Basket Vacuum Drying Pressure," and TS 4.2.1, "Storage System."
>
> This is a Severity Level IV Violation (Supplement VII).

Pursuant to the provisions of 10 CFR 2.201, Portland General Electric, is hereby required to submit a written statement or explanation to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, D.C. 20555 with a copy to the Regional Administrator, Region IV, within 30 days of the date of the letter transmitting this Notice of Violation (Notice). This reply should be clearly marked as a "Reply to a Notice of Violation" and should include for each violation: (1) the reason for the violation, or, if contested, the basis for disputing the violation or severity level, (2) the corrective steps that have been taken and the results achieved, (3) the corrective steps that will be taken to avoid further violations, and (4) the date when full compliance will be achieved. Your response may reference or include previous docketed correspondence, if the correspondence adequately addresses the required response. If an adequate reply is not received within the time specified in this Notice, an order or a Demand for Information may be issued as to why the license should not be modified, suspended, or revoked, or why such other action as may be proper should not be taken. Where good cause is shown, consideration will be given to extending the response time.

If you contest this enforcement action, you should also provide a copy of your response, with the basis for your denial, to the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, D.C. 20555-0001.

Because your response will be placed in the NRC Public Document Room (PDR), to the extent possible, it should not include any personal privacy, proprietary, or safeguards information so that it can be placed in the PDR without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request withholding of such material, you must specifically identify the portions of your response that you seek to have withheld and provide in detail the bases for your claim of withholding (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.790(b) to support a request for withholding confidential commercial or financial information). If safeguard's information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21.

In accordance with 10 CFR 19.11, you may be required to post this Notice within two working days.

Dated this 26th day of October 1999

ENCLOSURE 2

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

Docket Nos.:	50-344;72-17
License Nos.:	NPF-1;SNM-2509
Report No.:	50-344/99-07;72-17/99-05
Licensee:	Portland General Electric Company
Facility:	Trojan Nuclear Plant
Location:	121 S. W. Salmon Street, TB-17 Portland, Oregon
Dates:	May 20-June 1, June 30 thru July 1, July 10-21 and August 4-5, 1999
Inspectors:	J. V. Everett, Senior Health Physics Inspector, Region IV D. L. Rice, Health Physics Inspector, Region IV R. S. Carr, Health Physics Inspector, Region IV J. J. Petrosino, Inspector, NRR T. J. Kobetz, Project Manager, Spent Fuel Project Office
Approved By:	D. Blair Spitzberg, Ph.D., Chief Fuel Cycle & Decommissioning Branch Division of Nuclear Materials Safety
Attachment:	Supplemental Information

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EXECUTIVE SUMMARY

Trojan Nuclear Plant
NRC Inspection Report 50-344/99-07;72-17/99-05

The first TranStor™ basket arrived at the Trojan site on May 21, 1999. During the receipt inspection process, the basket was rinsed with demineralized water. The resulting rinse water was observed to be cloudy with a yellow tint. The cause was determined to be from the coating that had been applied to a small portion of the basket internals which had not been cured at high temperatures. The uncured coating was removed by rinsing the basket. On July 7, 1999, the basket was placed in the cask loading pit adjacent to the spent fuel pool in preparation for fuel loading activities and on July 12, 1999, the first fuel assemblies were placed in the basket. Eight fuel assemblies were loaded into the basket before water clarity problems prevented further loading. The fuel assemblies were removed from the basket on July 23, 1999, and returned to the storage racks in the spent fuel pool.

During the loading of the first basket, interaction between the uncoated carbon steel in the basket internals and the spent fuel pool water caused the generation of hydrogen gas and the formation of a precipitate that caused considerable clouding of the water in the cask loading pit. This unexpected condition resulted from the basket not being 100 percent coated as originally planned in the design of the basket.

As a result of the water clarity problem that occurred, the licensee and the cask vendor, BNFL Fuel Solutions initiated an extensive evaluation process to determine corrective actions. Further analysis of the coating and the process for applying the coating will be included in this evaluation. Further loading of fuel is on hold until resolution of the issues related to the coating and approval of the license amendment committed to in a letter from the licensee dated
July 20, 1999.

Operations of an ISFSI

- Loading of the first TranStor™ basket has been placed on hold at Trojan until resolution of issues concerning the use of the coating on the carbon steel portions of the basket and approval of the license amendment committed to in its letter to the NRC dated
July 20, 1999. BNFL Fuel Solutions and the licensee have initiated an extensive evaluation of the problem and are developing corrective actions. Issues to be resolved include hydrogen generation, heat transfer requirements for the coating, water clarity during loading and adhesion of the coating to the carbon steel (Section 1.2.b).

- Heat transfer (emissivity) calculations for the safety analysis report concerning the coating used on the basket's internal components had used a heat load for the basket of 26 kilowatts (kW). The license for the Trojan ISFSI had been issued for a heat load of 24 kW. Because of the age of the Trojan fuel, the maximum heat load that was determined for the Trojan baskets was 16.5 kW. With the lower heat load of the Trojan fuel, the licensee determined that no coating on the basket internals was needed to prevent internal basket temperatures from exceeding design limits. Therefore, from the perspective of emissivity, no coating would be required (Section 1.2.f).

- The licensee's calculations of the potential amount of hydrogen generated while borated water was in the basket and observation of the amount of gas generated while the basket was actually in the cask loading pit indicated that acceptable administrative controls could be implemented to maintain hydrogen levels below explosive limits during the welding of the cask lids. The licensee's procedures for welding the basket included provisions for purging the basket with inert gas and monitoring for hydrogen (Section 1.2.g).

- The licensee's evaluation of the interaction of the spent fuel pool water with the uncoated carbon steel in the basket and the dissolving of the basket coating in the spent fuel pool water determined there would be no adverse effects on the spent fuel cladding or the spent fuel pool clean-up systems (Section 1.2.h).

- The carbon steel portions of three shield lids had been coated, however the coating had only been flash cured. Flash curing did not involve the high temperature curing process required to fix the coating to the carbon steel. The licensee has removed the flash cured coating from the three shield lids and implemented controls to preclude further use of the coating on the shield lids (Section 1.2.i).

- No provisions had been made by the licensee to ensure that the coating manufacture's recommended 10-day cure time for the epoxy coating used on the external stainless steel surface of the basket was completed prior to placing the basket into the cask loading pit. This was a different type of coating than the coating applied to the basket internals. Had activities been conducted on schedule for the loading of the first basket, the cure time would have been only 7 days. The licensee corrected this issue by adding to the receipt inspection process a requirement to verify the 10-day curing period prior to using the basket (Section 1.2.j).

- Test results and actual observation during the time basket #1 was in the cask loading pit found that the external coating used on the stainless steel basket shell did not generate hydrogen or contribute to the water clarity problem (Section 1.2.j).

- An examination of the basket was performed after removal from the cask loading pit. The basket had been in the borated spent fuel pool water for 16 days. The basket passed the visual exam, coating thickness exam, ultrasonic thickness testing of the metal and boroscope examination of the welds. The basket did not pass the tape test for coating adhesion. Portions of the coating came off during the testing (Section 1.2.k).

<u>Design Control of ISFSI Components</u>

- Several safety evaluations conducted by the licensee to meet the requirements of 10 CFR 72.48 and 10 CFR 50.59 were reviewed. The problems identified during the NRC review of the safety evaluations indicated a general weakness with the implementation of the program (Section 2.2).

- A review of Safety Evaluation 200-1 determined that the licensee had incorrectly concluded that a change from using the overpack as a temporary container to a permanent container could be made without changing the technical specifications. The failure to identify the need for a change to the technical specifications (i.e., a license condition), was determined to be a violation of 10 CFR 72.48 (Section 2.2).

- The licensee performed a calculation to analyze whether the overpack could be removed from the concrete cask subsequent to a tip over event. The calculation had not adequately demonstrated compliance with the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel code requirements. This issue is considered an unresolved item pending further licensee analysis (Section 2.2).

Report Details

Summary of Facility Status

On March 31, 1999, the NRC issued Special Nuclear Material License SNM-2509 to Portland General Electric Company for use of the British Nuclear Fuels Limited (BNFL) Fuel Solutions TranStor™ Storage System. Thirty-four casks will be used to store the 780 spent fuel assemblies and the failed fuel cans currently stored in the spent fuel pool. The TranStor™ Storage System was designed by Sierra Nuclear Corporation. Sierra Nuclear Corporation is owned by British Nuclear Fuels, Limited. The main components of the TranStor™ Storage System were the PWR basket which holds the fuel, a concrete storage cask and a steel transfer cask. The basket consisted of a stainless steel shell with an internal arrangement of carbon steel cells and supports to hold the fuel assemblies. Each basket can hold 24 fuel assemblies. The carbon steel cells and internal supports were coated with a material to reduce the corrosive effects while emerged in the borated spent fuel pool water during loading and to promote heat transfer during storage.

Preparations for moving spent fuel from the spent fuel pool to dry cask storage at the onsite Independent Spent Fuel Storage Installation (ISFSI) was initiated on July 7, 1999, with the placement of Basket #1 into the cask loading pit. Final training was conducted with the fuel handling staff and on July 12, 1999, the first fuel assembly was placed in the basket. Over a period of 4 hours, eight fuel assemblies were placed in the basket. However, problems with water clarity and the ability to see the top of the basket resulted in fuel movement activities being stopped. Water clarity continued to decrease over the next several days. The licensee utilized several systems to clean-up the water and initiated an evaluation of the cause of the problem. The NRC also conducted an evaluation which centered on two potential causes of the water cloudiness. The first potential cause involved the interaction of a portion of the carbon steel basket internals that had not been coated and was showing evidence of interaction with the borated spent fuel pool water. The second potential cause of the clouding problem appeared to be the protective coating dissolving in the water.

On July 20, 1999, Portland General Electric Company committed to the NRC to submit a request for a license amendment revising the design of the basket to reflect less than 100 percent of the carbon steel being coated and the potential for hydrogen generation and mitigation of the consequences in accordance with the issues noted in NRC Bulletin 96-04. BNFL Fuel Solutions formed an independent evaluation team to assess the problems that were encountered during loading. Water clarity was regained by July 23, 1999, and the basket was safely unloaded. The spent fuel was returned to the spent fuel pool racks.

1 Operations of an ISFSI (60855)

1.1 Inspection Scope

This inspection provided for direct observation of the licensee's effort to load the first TranStor™ basket, including observation of fuel movement activities, problems encountered due to water clarity and generation of hydrogen gas bubbles and the post loading examination of the internal components of the basket after the fuel was unloaded.

1.2 Observation and Findings

a. Sequence of Events Prior to Placing Basket #1 into the Spent Fuel Pool

On May 21, 1999, the first TranStor™ basket arrived at Trojan. A receipt inspection was performed and the inside of the basket was rinsed with demineralizer water. After rinsing, the rinse water was observed to be cloudy with a yellowish tint. The licensee collected a sample of the rinse water for analysis and initiated ISFSI Problem Report IPR-156 on May 22, 1999. The shift manager reviewed the report and directed personnel to not place the basket into the spent fuel pool until issues related to the rinse water were resolved. The licensee initiated an effort to determine the source of the discolored rinse water including the chemical composition and the potential effects on the spent fuel pool. Later that same day, the basket was moved into the fuel building in preparation for eventual fuel loading.

Analysis of the rinse water sample by the licensee's chemistry department identified chromium concentrations of 180 ppm (parts/million). This was confirmed using an independent laboratory which measured concentrations of 200 ppm. Other chemicals also detected including manganese, aluminum and phosphorus. The chemicals identified in the rinse water were consistent with the chemicals known to be in the coating applied to the internal carbon steel cells. A small percentage of the coating had been brushed on by hand to portions of the basket internals and had not been heat treated in accordance with manufacturer's recommendations. The brushed on coating had been used for touch-up of carbon steel areas where welding had been performed. The intent was to fully coat all carbon steel surfaces to reduce the interaction between the carbon steel and the spent fuel pool water and to improve the appearance of the basket.

On May 24, 1999, Corrective Action Report (CAR) C-99-0026 "PWR Basket DI Water Washdown" was initiated to evaluate the unexpected problem with the coating and the potential effects of placing the basket in the spent fuel pool. BNFL Fuel Solutions was contacted and a hold was placed on any further use of the coating for touch-up. Only Basket #1 internals had been painted with touch-up paint. Approximately 1 quart of coating had been used. No touch-up painting had been performed on the internals in Baskets #2 and #3. However, the shield lids for all three baskets had been painted with the coating and flash cured. Flash curing did not involve the high temperatures associated with the full curing process and was later determined to not be effective in securing the coating to the metal. Flash curing was a process intended by the manufacturer to be a preliminary step prior to the high temperature curing process. The baskets and shield lids for Casks #1 and #2 had been delivered to the Trojan site.

A spare basket internal cell, consisting of a 4-sided sleeve, was available at the Trojan site to conduct tests of the coating. The cell had been manufactured to check for distortion and potential effects on cell dimensions and tolerances after the high temperature curing of the coating. On May 29, 1999, the end of the cell was suspended into a container of 2000 ppm boric acid/water solution. The boric acid solution was subsequently sampled and found to contain chromium. Initial chromium levels were measured at 6.4 ppm. These levels increased to 8.5 ppm at 30 hours, 9.0 ppm at 70 hrs, 11 ppm at 117 hrs and 12.2 ppm at 213 hrs. During phone conversations held with the vendor who supplied the coating, the licensee was told that there could be excessive chromium on the coating after curing that would be leachable when immersed in water. The yellow coloration in the water was due to the excessive chromium. After a period of immersion, the excessive chromium would leach off leaving the cured coating in place. Properly cured coating would be very insoluble.

At the end of 24 days, examination of the immersed coating surface on the spare basket internal cell did not show any abnormal indications. However, on June 4-5, 1999, visual examination of the cell on a portion of the coating not immersed in the boric acid, found that the coating easily flaked off with very little pressure applied during scratching with a fingernail. The spare cell had not been coated under a quality related purchase order and had not been quality control (QC) inspected. It was therefore assumed by the licensee that the coating may not have been properly applied.

On June 16, 1999, demineralized water was circulated through Basket #1 at a temperature of 160EF in an attempt to remove all uncured coating from inside the basket. Based on information from the coating vendor, all uncured coating would be water soluble. The demineralized water had previously been recirculated through Basket #2 to remove any uncured coating. The recirculation process used a mixed bed demineralizer and a cartridge filter. The system was shown to be very effective in removing the chromium in the water during the recirculation process on Basket #2. Initially, the chromium levels in Basket #1 were 1 ppm. After 12 hours, the levels were below 1 ppm. After the water was removed and the basket dried, small rust spots were observed on the coated carbon steel areas.

Samples of the water from the bottom of Baskets #1 and #2 were collected at the end of the water recirculation processes. The water contained a dark orange precipitate. The water was sent to an offsite laboratory for analysis and was found to contain iron oxide and hydrated metal oxides. The sample from Basket #2 had been darker, possibly reflecting the longer period of time the demineralized water had been in the second basket and the use of an air sparger to agitate the water.

On June 21, 1999, Baskets #1 and #2 were examined by the licensee's coatings expert who determined that the rust spots were due to microscopic pin holes in the coating and/or exposed peaks of the substrate profile. The peaks could be reduced by applying a smaller grit during sandblasting of the surface prior to applying the coating. The use of warm demineralized water to rinse the baskets had resulted in an accelerated corrosive environment for the carbon steel. This was especially true during the period in which the air sparger was used on Basket #2. Thus the rust spots formed very quickly at the microscopic breaks in the coating. Once the rust spots were cleaned off, the coating appeared to be intact.

The coating expert performed several field tests on the coating on Basket #2 including hardness tests (ASTM D3363, Standard Test Method for Film Hardness) and adhesion tests (ASTM D3359, Standard Methods for Measuring Adhesion by Tape Tests). The coating met the 7H+ hardness criteria which exceeded the vendor's recommendation of 6H+. The coating also passed the tape adhesion tests. The coating integrity was checked using a saturated copper sulfate solution applied to the surface of the coated area. Color on the surface would indicate a reaction with the carbon steel. The areas where reactions occurred were consistent with the areas where rust spots had been observed. Breaks in the coating were not visible without magnification. The coating expert concluded that in the boric acid environment in the spent fuel pool, the formation of rust spots would not be significant and the coating would perform its intended function of reducing the interaction between the carbon steel and the spent fuel pool water.

On July 9, 1999, the licensee completed a 10 CFR 72.48/50.59 safety evaluation (No. SE99-027) to allow for less than 100 percent coating of the carbon steel internals and to eliminate the use of touch-up and flash cured paint on the basket and shield lid. The licensee had estimated that a value of 10 percent uncoated surface area would provide a conservative estimate for analysis. The conservative 10 percent value was confirmed with BNFL Fuel Solutions.

Safety Evaluation SE99-027 considered the effects on emissivity and concluded that the heat transfer characteristics for the cask were still within the required limits established in the technical specifications basis document, section B3.1.1. The basis for the requirement for the coating in the original calculations assumed a heat load of 26 kilowatts (kW). Trojan specific calculations determined that 16.5 kW would be the maximum heat load for the Trojan fuel. At this heat load, a coating would not be required to meet the thermal design limits for the basket. However, Table 2-1 "Spent Fuel Limits," of Trojan's ISFSI license specified a heat load of 24 kW. Use of the 16.5 kW heat load for emissivity calculations would not encompass the heat load limits allowed by the Trojan safety analysis report. In addition, a review of Design Calculation PGE01-10.02.04-15, Revision 2 "Thermal Effects of Uncoated Internal Surfaces in TranStor™ PWR Baskets" appeared to have design calculations that did not bound the lower emissivity value for all operating conditions. The issue of the use of the 16.5 kW heat load and the bounding of the lower emissivity values will be addressed during the review of the licensee's submittal for a change to the safety analysis report addressing the coating issue.

The potential for a galvanic reaction between the stainless steel boral attachment pins and the uncoated carbon steel cell surfaces was also evaluated in Safety Evaluation SE99-027. Both the licensee's metallurgist and BNFL Fuel Solutions determined that the effect of a galvanic reaction would not result in corrosion that would reduce the ability of the pins to secure the boral attachments. This was based on the relative size of the stainless steel and carbon steel surfaces. No evaluation was completed of the potential galvanic reaction between the bottom of the stainless steel basket and the uncoated portions of the internal cells that could come into contact with the basket. This was later evaluated by BNFL Fuel Solutions at the request of the NRC and determined to not be a significant contributor to the water clarity and hydrogen generation problems that occurred during fuel loading.

Safety Evaluation SE99-027 discussed corrosion products that could form on the uncoated carbon steel surfaces. The licensee determined that the corrosion products would not create a problem for emissivity, welding, vacuum drying or structural integrity of the basket. The safety evaluation stated that removing the touch-up paint had no effect on the allowed duration of basket immersion in the spent fuel pool. This was because the corrosion products and potential clouding would be controlled through the use of the spent fuel pool cooling and cleanup system.

Safety Evaluation SE99-027 addressed whether the proposed activity created the possibility of an accident of a different type than any already evaluated in the Trojan nuclear plant and/or ISFSI safety analysis reports. The licensee concluded in the safety evaluation that no unreviewed safety question was involved with the change to allow for uncoated surfaces on the basket internals. The licensee justified this conclusion by stating, “Allowing uncoated carbon steel surfaces to come in contact with borated spent fuel pool water creates the potential for small quantities of hydrogen gas to be generated. Portland General Electric has added procedural controls over ISFSI welding operations to prevent hydrogen ignition.”

The licensee’s safety analysis report for both the Part 50 license and the Part 72 license did not address the potential for hydrogen generation or an accident associated with the ignition of hydrogen during basket loading and welding. No discussion was included in the Safety Analysis Report, Section 5.1.1.2 “Basket Loading and Sealing Operations,” concerning administrative or mitigating controls for hydrogen during welding of the basket lid.

Based on the safety analysis report submitted by Portland General Electric to the NRC and subsequent discussions during the approval process and issuance of the license for the Trojan ISFSI, the TranStor™ basket was not expected to generate hydrogen. At no time during the licensee review process was the NRC informed by the licensee that hydrogen generation would occur during the loading of the basket, and in fact, when the basket was initially placed in the cask loading pit and bubbles were observed, the licensee initially provided explanations of trapped air or leaks in the demineralizer system recirculation line as the sources of the bubbles. Therefore, the NRC considers the generation of hydrogen in a TranStor™ basket to be a new issue not described in the Trojan ISFSI Safety Analysis Report or the Trojan Defueled Safety Analysis Report. By a letter dated July 20, 1999, the licensee committed to submit a license amendment to revise the safety analysis report to reflect the use of the TranStor™ basket with less than 100 percent coating and to address the potential for hydrogen generation in the basket.

The licensee had originally not included controls for potential hydrogen generation in their welding procedures for the TranStor™ baskets. During the dry run exercise conducted by the licensee on March 29-April 8, 1999, the NRC identified the need to include controls for monitoring hydrogen for the prototype basket being used in the dry run. This prototype basket was coated with a CarboZinc coating, which was known to generate hydrogen. The licensee had not evaluated the hydrogen issue for the prototype basket. Subsequent to conversations with the NRC, hydrogen monitoring was added to the welding procedures for the CarboZinc coated basket. This issue was documented in NRC Inspection Report 50-344/99-04;72-17/99-02 dated May 7, 1999. Upon completion of the dry run exercise with the CarboZinc coated basket, the requirement for hydrogen monitoring was removed from the welding procedures.

The requirement to monitor for hydrogen was not initially incorporated into the TranStor™ basket welding procedures because hydrogen had not been observed during the qualification testing of the coating. As a result of the analysis performed as part of Safety Evaluation SE99-027, Temporary Change Notice TCN # T99-053 was issued June 3, 1999, to revise procedure FHP 50-06 “Welding ISFSI Basket and Overpack Components,” to include monitoring for oxygen and hydrogen. Page 21, Step 4 of the procedure specified that an inert gas purge was to be established for 1-hour prior to welding. At the end of an hour, oxygen monitoring was to be performed. If oxygen levels exceeded 4 percent or if the hydrogen alarm point was exceeded, welding was not allowed. The hydrogen alarm point was 25 percent of the lower flammable limit. This would equate to a hydrogen alarm point of 1 percent hydrogen.

b. <u>Loading of Basket #1</u>

Basket #1 was placed in the cask loading pit on July 7, 1999, to allow additional training of the certified fuel handlers over the next several days. The cask loading pit is adjacent to and connected to the spent fuel pool. A gate can be closed to isolate the cask loading pit from the spent fuel pool. NRC inspection personnel arrived July 10, 1999. By July 10, a brownish colored water had developed in the lower portions of the basket and bubbles were observed coming from the basket. The licensee explained the bubbles as an air leak into the recirculation pump suction line that was part of the demineralizer system providing water flow to the cask loading pit. A second worker identified the air bubbles as possible trapped air from inside the internal components of the basket. A third explanation was possible interaction between the neutron absorbing material attached to the internal sleeves and the borated spent fuel pool water.

On July 10, 1999, the licensee attempted to filter the cloudy water in the basket using an underwater vacuum/filtering system. The system was configured to discharge into the main portion of the spent fuel pool. The filters initially used were too porous resulting in cloudiness in the spent fuel pool water. Discharge of the water from the basket into the spent fuel pool was stopped. Over the next couple of days, the spent fuel pool water was filtered and cleaned through the spent fuel pool clean-up system. The clarity of the spent fuel pool water was returned to normal.

Water samples from the cask loading pit taken on July 9, 1999, indicated 4.9 ppm iron, 0.04 ppm chromium, 2222 ppm boron and a pH of 4.95. By July 11, the iron level had increased to 18.5 ppm. The cask loading pit water was relatively clear, but the water inside the lower portion of the basket was dark brown in color. Gas bubbles were still coming from inside the basket.

On July 12, 1999, at 1:30 a.m., fuel movement activities began. As each fuel assembly was moved into the cask loading pit, all four sides were examined by an underwater camera to verify the integrity of the fuel assembly. By 5:44 a.m., eight fuel assemblies had been loaded into the basket. The loading of the fuel assemblies into the basket agitated the cloudy water in the bottom of the basket. By the time the eight fuel assembly had been loaded, visibility into the basket was insufficient to see the top of the cells. The licensee terminated loading activities and installed the gate separating the spent fuel pool from the cask loading pit. Water clarity continued to degrade over the next several days to the point that visibility in the cask loading pit was about 1-foot. Heat generated by the fuel assemblies in the basket contributed to the movement of the cloudy water from the basket into the cask loading pit.

On the morning of Monday, July 12, 1999, the NRC inspection team leader contacted the NRC project manager in NRC Headquarters, assigned to the Trojan ISFSI and discussed the water cloudiness problem and the bubbles. A review was performed of the safety analysis report to determine if any information concerning these issues was provided. Discussions with NRC management were initiated to review the conditions being experienced at Trojan concerning the continued evidence of gas bubbles being generated by the basket and the water clarity problem.

On July 13, 1999, gas samples were collected by the licensee from the cask loading pit for analysis. A rough estimate of gas formation based on the rate of collection of gas indicated a rate of 1 liter per 4-6 hours or about 1/4 liter/hour. The samples were sent to an offsite laboratory for analysis. The sample results indicated 45 percent hydrogen, 7.5 percent oxygen, trace amounts of carbon dioxide and methane and 45 percent unknown. When the laboratory was contacted concerning the unknown gas, they stated that the hydrogen peak was so large that it masked other peaks and they were not sure what the unknown gas was. A second sample was sent on July 15, 1999, for additional analysis of the unknown. This sample resulted in an analysis of 47 percent hydrogen, 7.5 percent oxygen, and 45 percent nitrogen. A separate sample was sent to a second laboratory for analysis. However, problems with their system yielded no reliable results. The iron concentration in the cask loading pit water had dropped to 1.37 ppm from the 18.5 ppm measured on July 11, 1999. This was the result of the licensee increasing the flow rate on the demineralizer system.

On July 16, 1999, the water in the cask loading pit appeared to have a more yellow tint than the brown coloration that had been observed over the previous several days. Over time, as the demineralizer system removed the iron, the yellow coloration of the dissolved coating became more predominant. The demineralizer system was not effective in removing the dissolved coating from the cask loading pit. Water clarity had not improved and visibility continued to be about 1-foot when looking down into the pool from the refueling floor. Crud was observed floating by the underwater camera. This was the first time crud had been observed by the NRC inspectors in the cask loading pit. Iron content in the water continued to decrease due to the filtration of the water through the demineralizer system. Iron levels were down to 0.65 ppm on July 16. Iron levels measured in the water being returned to the cask loading pit from the demineralizer system were 0.27 ppm, indicating the demineralizer system was still reducing the iron levels. Bubbles had reduced significantly. The pH of cask loading pit was 5.5.

A conference call was conducted on July 16, 1999, between the NRC, the licensee, and BNFL Fuel Solutions to discuss the status of the cask loading effort. BNFL Fuel Solutions provided results of new calculations for the generation rate of hydrogen. The calculations showed that with 10 percent carbon steel uncoated, up to 8 liters/hour of hydrogen could be generated. This assumed a pH of 4 and 180EF borated water. This was more conservative than the current cask loading pit conditions of pH 4.94 - 5.5 and temperature of 100EF. Based on actual collection of gas bubbles rising to the surface in the cask loading pit, approximately 1/4 liter/hr of gas was observed. With 45 percent hydrogen, then only 1/8 liter/hr of hydrogen was being observed. This was considerably lower than the calculated values.

On July 19, 1999, the cask loading pit water clarity had not improved. Bubbles were still observed, but at a much reduced rate. At 1:00 p.m., a conference call was conducted between the licensee, NRC headquarters, and Region IV. During this conference call the licensee committed to submit a license change request for the safety analysis report. This license change request would include an evaluation of the basket against the issues identified in NRC Bulletin 96-04. The licensee also committed to unload the basket and perform a visual inspection to verify the condition of the basket. The licensee understood that future fuel loading would not be initiated until after the NRC had reviewed and accepted the license change. A letter concerning these commitments was sent from the licensee to the NRC on the following day.

On July 20, 1999, the Tri-Nuclear underwater cleanup system with smaller filters was started and operating at 270 gallons/minute. This system was intended to remove the dissolved coating from the cask loading pit water. Tests in the licensee’s chemistry laboratory had found that a 3 mil filter was effective in removing the dissolved coating. Prior to using the system, cloudiness of the water and generation of bubbles had not changed from the previous day. Turbidity in the cask loading pit was measured at 12 NTU (Nephelometric Turbidity Units). The spent fuel pool, where water clarity was excellent, had a turbidity level of 0.27 NTU. The gate between the cask loading pit and the spent fuel pool had been maintained closed ever since the eight assemblies had been inserted into the basket.

By July 21, 1999, the water clarity in the cask loading pit had improved to the point that visibility was 10-12 feet. The basket could be seen on the underwater camera located along the wall of the cask loading pit. Turbidity was down to 5.8 NTU.

On July 23, 1999, clarity had improved to the point the fuel assemblies were visible. The fuel assemblies were successfully unloaded and returned to the storage racks in the spent fuel pool. The basket was moved from the cask loading pit to the cask wash pit in the fuel building.

Further loading of baskets at Trojan have been placed on hold until resolution of issues concerning the use of the coating on the carbon steel portions of the basket. BNFL Fuel Solutions and the licensee have initiated an extensive evaluation of the problem and are developing corrective actions.

c. Trojan Safety Analysis Report Description of the Basket and Coating

On March 31, 1999, the NRC issued Special Nuclear Material License SNM-2509 to Portland General Electric for the TranStor™ storage cask. No restrictions or provisions were included in the license or technical specifications for hydrogen generation. The NRC's understanding of the basket design and coating being used was that hydrogen would not be generated. This was based on the testing and qualifications program that had been completed for the coating and the description of the basket in the safety analysis report.

The May 3, 1999, Revision 0 of the Trojan ISFSI Safety Analysis Report described the basket in Section 4.2.4.2.1. The description of the basket in the safety analysis report stated "The PWR basket internal carbon steel components are coated with an inorganic, radiation resistant, high temperature coating to provide corrosion protection during immersion in fuel pool water and to promote radiant heat dissipation." Section 4.2.4.2.8 also referred to the basket's carbon steel internals as being coated. Table 4.2-13 "Thermal Properties" provided an emissivity value for coated and bare stainless steel, but only provided an emissivity value for coated carbon steel. The value was 0.8. Table 4.2-15 "PWR Basket Overpack Coating Criteria" provided a list of the criteria for the coating for the basket interior. The emissivity value listed in Table 4.2-15 was 0.8, which was the value for the coated carbon steel. Note 2 to Table 4.2-15 stated "No generation of volatile organic compounds or flammable gases are allowed." Throughout the safety analysis report, no discussion of the potential for hydrogen generation or the need for precautions related to hydrogen being present was provided. This included Section 5.1.1.2 which discussed the basket loading and sealing operations, Section 5.2.1.1.5 which discussed the welding system to be used, Section 6.2 which discussed radiological gases that will be drawn off the cask during vacuum drying and Table 9.2-1 "Pre-operational, Start-up, and Other Tests," which provided the objectives of the basket welding and cutting that would be demonstrated in the pre-operational testing program. Based on the information in the safety analysis report submitted to the NRC, no indication was provided by the licensee that the carbon steel would be coated less than 100 percent or that hydrogen gas would be generated during the process of loading and welding the basket.

The concept of 100 percent coated carbon steel internals for the basket was also reflected in Question #3 to Attachment 3 of Safety Evaluation SE99-027 completed by the licensee. Question #3 asked “Does the implementing activity involve a change to the Trojan Nuclear Plant or ISFSI Facility as described in the safety analysis report.” The licensee’s basis for responding “yes” to the question related to the Part 72 evaluation which stated that certain sections of document PGE-1069 (Trojan ISFSI Safety Analysis Report) will require revision because they imply that the basket internals are 100 percent coated.

d. History of Selection of the Coating Used on the TranStor™ Basket

On May 28, 1996, during fuel loading of a Sierra Nuclear VSC-24 basket at the Point Beach Nuclear Power Station, a hydrogen burn was experienced during the welding of the root pass weld on the shield lid. The hydrogen burn was sufficient to cause the shield lid to lift up slightly. On July 5, 1996, the NRC issued Bulletin 96-04 directing the users of casks to evaluate the potential for a hydrogen explosion and identify mitigating actions that could be taken to prevent the problem. Portland General Electric, at that time, was working with Sierra Nuclear, Inc. to obtain a license for the TranStor™ design to be used at Trojan.

Sierra Nuclear, Inc. responded on August 16, 1996 to NRC Bulletin 96-04 concerning the design of the VSC-24 cask. In their response, Sierra Nuclear, Inc. identified both the reaction between the CarboZinc coating and the spent fuel pool water, as well as the uncoated carbon steel reacting with the spent fuel pool water as sources of hydrogen gas. The portion of the VSC-24 cask that was uncoated was the area where the lid closure welds would be made. The amount of hydrogen that would be generated by the uncoated portions of a VSC-24 cask was identified as very small and was expected to be less than the hydrogen generated by the CarboZinc coating and by radiolysis. Sierra Nuclear, Inc. also committed to evaluate alternative coatings for use in their casks. In a letter dated November 20, 1996, Sierra Nuclear, Inc., committed to the NRC to discontinue the use of CarboZinc as a coating if an alternate coating could be successfully qualified. No response to Bulletin 96-04 was made by Portland General Electric, since they were not a licensee at that time.

During 1997 and 1998, coatings were evaluated and tested by NWT Corporation for Sierra Nuclear, Inc. for use on the TranStor™ basket. Fourteen coatings went through the evaluation process. Sierra Nuclear, Inc. issued a Coatings Qualification Program Report on August 12, 1998. At approximately the same time, NWT Corporation Report #582 was issued which noted a yellow solution resulting from the tests on coated metal test samples, however, the report did not provide an analysis of the chemical composition of the solution. On August 19, 1998, Revision 1 to the Coatings Qualification Program Report was issued and referenced the NWT Corporation Report #582, however, the Coatings Qualification Program Report did not mention the yellow solution observed during the tests. Two coatings were identified as acceptable potential replacements for the CarboZinc coating. Evaluations of the coatings included adhesion, radiation effects, emissivity and chemical reaction with boric acid. Coating #1 required a high temperature baking process to cure the coating. Coating #2 did not require this process. In February 1999, the licensee realized that all the required tests could not be completed for Coating #2 in time to support Trojan's planned fuel loading schedule. In particular, a source for the high radiation testing was not available. At this point, Coating #2 became an alternate coating and the decision was made in March 1999 to proceed with Coating #1 as the selected coating.

Coating #1 had been developed 15 years earlier to provide aircraft, aerospace and marine equipment industries with a material to protect components from high temperature oxidation, salt laden atmospheres, chemicals and abrasives. The coating was intended to protect steel from oxidation following exposure to high temperatures and open flames. The product data sheet for the coating identified water as the method for clean-up. Materials identified for application of the coating included ceramic, carbon steel, steel castings and stainless steel. The process for curing was specified in the product data sheet. Flashing was recommended to remove the volatile portions of the coating from the film prior to final cure. The cure schedule was specified as (1) “flash” 10 minutes at 175EF, (2) cure 30 minutes at 650EF or 10 minutes at 750EF.

The manufacturer’s recommended curing process for coating #1 involved heating the coating to 750EF for 10 minutes or 30 minutes at 650EF. A concept of flash curing could be used to drive off moisture to allow for handling of the coated parts. Flash curing involved a temperature of 175EF. Flash curing would not fully cure the coating. High temperatures were necessary to cure the coating.

The basket fabrication process involved spraying the carbon steel cells and internal supports with the coating, then baking the material at the required high temperatures to cure the coating. Those areas where welding would be needed during assembly were left uncoated. To coat those areas required the basket internals to be returned to the paint shop after welding. Up to three trips to the paint shop could be required to achieve 100 percent coating of the carbon steel internals. The fabricator was asked to determine how much uncoated area would result from a fabrication process that involved only one trip to the paint shop. Since the paint shop was several hundred miles from the fabrication shop, a week delay would be experienced each time a trip to the paint shop occurred. The fabricator identified that one trip to the paint shop would result in approximately 4 percent of the basket being uncoated.

Based on some anecdotal evidence during the testing of the baked coupon, BNFL Fuel Solutions apparently believed it possible to touch up the small uncoated areas without baking or curing the coating. This would improve the look of the finished product. To validate this, BNFL Fuel Solutions directed Hitech in April 1999 to prepare a series of samples with uncured coating and send to the laboratory for testing. These samples were exposed to a boric acid solution and while some coating came off in the overlap areas, there was sufficient coating remaining on the carbon steel to preclude rusting. Based on this test program, touch up of the uncoated carbon steel was allowed. This direction was issued in a memo dated April 19, 1999, from BNFL Fuel Solutions to Hitech. However, BNFL Fuel Solutions did not evaluate the potential turbidity of the water which ultimately caused the water to be too cloudy to see the cask and move fuel.

e. Coating Reports for the TranStor™ Basket

The original TranStor™ Coatings Qualification Program Report (SNC-213-03-27) was issued August 12, 1998. Revision 1 was issued on August 18, 1998, and incorporated information on the results of the radiolytic decomposition calculation review, analysis of coating precipitate and wording on additional CarboZinc testing. On October 26, 1998, Revision 2 of the qualifications report was issued. This revision added information on one of the other coatings that had been tested.

The acceptability of using the uncured coating was incorporated into the Coatings Qualification Program Report and forwarded to the licensee on May 19, 1999, as an unsigned, advanced copy of Revision 3 of the report. Evaluation of the use of uncured coating on the cask had been requested by the licensee. Section 4.1.1 of the advanced copy of the coatings report stated that testing had been done to address the effects of the use of touch-up coating and that the touch-up coating had passed a range of tests. These tests had been conducted by NWT Corporation and issued to BNFL Fuel Solutions as NWT Corporation Report #597, dated May 1999. A copy of this report had been faxed to the licensee on May 19, 1999.

On May 24, 1999, after the discolored rinse water problem was observed at Trojan, the licensee reviewed NWT Corporation Report #597. The report provided results of tests conducted on the effects of boric acid solution on samples of hand brushed, uncured coating. The concentration of the boric acid solution simulated the concentration found in a typical spent fuel pool environment. The report indicated the presence of chromium in the boric acid sample solution (7 to 11 ppm). The solution had also changed from clear to a cloudy yellowish color. There appeared to be sufficient coating remaining on the carbon steel to preclude any significant corrosive effects. The results of the tests were considered acceptable based on no gas bubbles or corrosion of the test specimens being observed. The review of the report by BNFL Fuel Solutions did not identify a concern with the chromium observed because of the low levels measured.

The original tests conducted by NWT Corporation on the cured coating were reviewed again by the licensee. NWT Corporation Report #582, issued in August 1998, had identified a yellow coloration during the first 8 hours of the boric acid solution tests. Continuous exposure resulted in a more intense yellow color and yellow precipitate that appeared to turn into an orange then dark amber color. Because of the color change, attention was focused solely on the possible existence of iron in the precipitate and analysis of other chemical constituents, including chromium, was not performed.

On July 6, 1999, Revision 3 of the Coatings Qualification Program Report was approved and issued by BNFL Fuel Solutions to include additional test analysis for the coating. Revision 3 of the report stated that the selected coating had passed the various tests to qualify it for use on the basket. Section 4.1.1 of the report stated that “the additional testing of the coating found that minimal leaching and precipitation did occur, however, this material posed no detrimental effects on the coating systems integrity. In addition, post test observations indicated that some minor checking, discoloration and pitting was evident. However, these indications were also determined to be of no significance to the coating systems performance.” The conclusion to Section 4.1 of the report stated that “the coating successfully completed all sequential exposures in boric acid, boric acid tolerance at elevated temperatures, high temperature exposure and radiation exposure. The successful completion of this testing sequence provides assurance that when properly applied, the coating system is qualified for the TranStor™ system.” The final report issued July 6, 1999, was different than the unsigned draft copy sent to the licensee in May for review. The final report, Revision 3, specified that the coating was qualified when properly applied. The May draft version of Revision 3 of the report had stated that touch-up coating had also passed the testing. However, this statement was not in the final version of Revision 3.

f. Heat Transfer (Emissivity) Requirements

In November 1998, preliminary scoping calculations had been performed by BNFL Fuel Solutions to determine the effects on the heat transfer (emissivity) aspects of the basket with portions of the carbon steel not coated. The calculations were not finalized as a design document, but indicated that for the heat load for the Trojan fuel of 16.5 kW, no coating was necessary to meet the design criteria for the basket. The long term design criteria temperature limit for normal conditions of storage for the spent fuel cladding was 705EF. The short term temperature limit was 1058EF. The design criteria temperature limits for the basket are discussed in the Safety Analysis Report, Section 4.2.6 and the basis document for the Trojan Technical Specifications, Section B3.1.1. The technical specifications establish a limit of 24 kW for the fuel placed in the TranStor™ basket. The safety analysis report used a more conservative value of 26 kW for the emissivity calculations.

The worst cases fuel clad temperature conditions for the basket would be during basket vacuum drying while in the transfer cask and long term storage of the basket in the overpack. Calculations for these conditions were formalized by BNFL Fuel Solutions and issued as calculation numbers PGE01-10.02.04-13, PGE01-10.02.04-15 and PGE01-10.02.04-16 in June 1999. These calculations assumed no internal basket coating was used. For the worst case vacuum drying condition, the resulting maximum cladding temperature was 789EF. This was less than the 888EF calculated value in the safety analysis report for peak temperature during cask vacuum drying and well below the 1058EF short term temperature limit. For the long term storage of the basket in the overpack, the limiting factor would be the 225EF temperature limit for the concrete. The calculations determined that the maximum concrete temperature would reach 151EF for the Trojan fuel with an uncoated basket.

g. Hydrogen Generation

During March 29 through April 8, 1999, the licensee conducted a pre-operational dry run exercise in preparation for loading the first cask. This exercise was observed by the NRC and was documented in NRC Inspection Report 50-344/99-04;72-17/99-02 dated May 7, 1999. The exercise was performed using a prototype basket that was coated with CarboZinc coating instead of the coating that was planned for the TranStor™ baskets. Prior to performing the exercise, Trojan draft Procedure FHP 50-06, "Welding ISFSI Basket and Overpack Components," Attachment 3 "Shield Lid Weld Traveler" Step 4 under the section on shield lid basket weld fit-up, required purging with an inert gas prior to and during welding. The procedure did not require monitoring for hydrogen. After discussions with the NRC inspection team and prior to welding operations during the dry run, Trojan revised the procedure to include hydrogen monitoring since the cask being used for the exercise was coated with CarboZinc, which was known to generate hydrogen while in contact with borated water.

After the dry run exercise was completed with the CarboZinc coated basket, the provisions for hydrogen monitoring were removed from the procedure. When the water soluble problem with the coating occurred during the receipt inspection wash-down of the new basket on May 21, 1999, and the uncured coating was removed, the licensee recognized the potential for hydrogen generation between the uncoated carbon steel and the spent fuel pool water and revised Procedure FHP 50-06, per Temporary Change Notice (TCN) # T99-053, to return the requirement for hydrogen monitoring to the procedure. The procedure established a flow rate requirement of 30 cubic feet per hour of inert gas (argon or nitrogen) under the lid for at least 1-hour prior to welding. This provided for three volume changes per hour of the air in the basket. Work was required to be stopped when the explosives detector alarmed or oxygen levels exceeded 4 percent. The alarm on the explosives meter was set at 25% of the lower flammable limit of hydrogen, which would be 1 percent hydrogen. The licensee believed that the oxygen level was the more important parameter. As long as the oxygen level remained below 6.5 percent, no flammable condition could exist in the basket, no matter how much hydrogen was present.

The TranStor™ Coatings Qualification Program Report, Revision 3, Section 2.2.2 “Boric Acid Off-Gas Verification,” had included a discussion of the potential for hydrogen gas generation due to radiolysis and chemical reaction between the coating and the spent fuel pool water. Section 2.2.2 stated that typically, procedural controls would be used to mitigate the possible adverse effects associated with the presence of hydrogen by venting the air space in the basket and sampling the gas prior to seal welding the shield lid. The coatings qualification program report specified that visual examinations would be completed of the coated coupons in the boric acid solution at specific time periods to ensure there was no excessive creation of gas within the acid solution. Section 4.1.1 of the Coatings Qualification Program Report provided the qualifications program results and stated that no significant off-gassing had been observed from the coating during the boric acid testing.

Detailed calculations for hydrogen generation of a 10 percent uncoated basket were first completed on July 16, 1999, and presented to the NRC during a conference call on the hydrogen issue. Calculated hydrogen rates were 8 liters/hour. Based on the value of 8 liters/hour of hydrogen, the flow rate of 30 cubic feet/hour (850 liters/hour) could be shown to be adequate to keep the explosive concentrations well below the flammable limit for hydrogen. When considering that the actual observed gas generation rate was 1/4 liter per hour and the results of the analytical analysis indicated 45% of the gas was hydrogen and 7.5 percent oxygen, then the inert gas flow rate of 850 liters/hour would result in a hydrogen concentration of approximately 0.015 percent. This was well below the lower flammable limit for hydrogen of 4 percent.

Safety evaluation SE99-027, dated July 9, 1999, addressed the potential for hydrogen generation. The safety evaluation took credit for administrative procedure controls established during welding to prevent hydrogen ignition. These controls, established in Procedure FHP 50-06, would have adequately provided for controlling and monitoring the hydrogen.

h. Effects of the Coating on the Spent Fuel Pool

The licensee recognized that the potential water solubility of the uncured coating while in the spent fuel pool created concerns related to the effect of the chemical constituents of the coating on the spent fuel, spent fuel racks and the demineralizer resins. The fuel assemblies consisted primarily of 304 stainless steel, Inconel 718 and Zircoly-4. The primary chemicals in the coating were chromium, iron, aluminum, manganese and phosphorus. The licensee also considered the precipitate that had been identified with the uncoated carbon steel. The primary product resulting from the uncoated carbon steel interacting with the borated spent fuel pool water was corrosion products containing iron.

Westinghouse Electric Corporation, manufacturer of the reactor fuel used at Trojan, was contacted by the licensee by letter on June 3, 1999, requesting evaluation of the effects of the chemicals on the fuel. On June 8 and June 22, 1999, e-mails were received from Westinghouse stating that the chemicals identified in the coating were not a hazard to the fuel assembly structural components. Based on the chemical composition of the coating, Westinghouse determined that accelerated corrosion of Zircoly components and stress corrosion cracking of stainless steel components were unlikely. The analysis by the licensee agreed with the Westinghouse conclusion and also determined that the effects on the spent fuel pool racks and Boraflex would be minimal.

The effects of the various chemicals that could dissolve in the spent fuel pool water and be processed through the spent fuel pool clean-up system and the cask loading pit clean-up system were evaluated. The effects of chromium on the demineralizer system was of primary concern because of the potential to create a mixed waste product in the ion exchange resin that would be difficult to dispose of. A Toxicity Characteristics Leaching Procedure (TCLP) test was performed on the resins for both the spent fuel pool and the cask loading pit demineralizer systems for chromium. The analysis performed by PN Services, dated May 28, 1999, determined that the chromium would tightly adhere to the resin beads and would not create hazardous waste. The other chemicals in the coating were also determined to be acceptable for processing through the demineralizer system.

The technical specifications for the Trojan Part 50 license did not establish specific limits for chemicals in the spent fuel pool except for Technical Specification 3.1.2 which required a minimum of 2000 ppm of boron to be maintained in the spent fuel pool water. Maintaining and implementing a chemistry control program was a requirement of Technical Specification 5.7.2.8. The licensee maintained a chemistry control program for the spent fuel pool, including procedures TPP 26-2 “Spent Fuel Pool Water Chemistry Program” and TPP 14-10 “Requirements for Materials Contacting Spent Fuel Pool Systems.” The licensee compared the chemical composition of the coating with the limits established by the chemistry control program and determined that the coating would not exceed any of the limits.

i. <u>Coating of the Shield Lid</u>

Coating had been applied to the carbon steel portion of the shield lid bottom plates on Baskets #1 thru #3. Shield Lids #1 and #2 had been delivered to the Trojan site at the time of this inspection. Shield Lid #3 was still at the manufacturer’s shop. The coating on all three lids had not been cured at the high temperature needed for full curing, but had been flash cured. Flash curing was a quick heat process at 175E F and was intended by the manufacturer as a first step in curing the coating to drive off moisture. Flash curing was to be followed by high temperature curing. However, a misunderstanding of the effectiveness of the flash curing process to fix the coating to the carbon steel resulted in flash curing being considered as an acceptable method for applying the coating to the shield lids. BNFL Fuel Solutions Nonconformance Reports NCR No. PGE01-TSP-01, generated on May 27 and closed on July 7, 1999, and NCR No. PGE01-TSP-02, generated on June 2 and closed on July 8, 1999, specified that the coating on the shield lids was to be removed. Removal of the flash cured coating on the three lids was completed on June 9, 1999.

On July 9, 1999, the licensee completed Safety Evaluation SE99-027 concerning the problem with the touch-up paint. This safety evaluation documented that the shield lids did not require coating. The safety evaluation referenced BNFL Fuel Solutions calculation PGE01-10.02.05-12, dated July 6, 1999, which evaluated the corrosion aspects of the shield lid not being coated and found that minimal corrosion would occur.

j. <u>External Coating on the Basket</u>

An epoxy coating was applied to the external surface of the basket. This coating was different than the coating applied to the carbon steel internal structures. The epoxy coating was intended to reduce contamination of the stainless steel outer surface while the basket was in the spent fuel pool water. This would make clean-up of the outer surface easier. During loading of the basket, no bubbles were observed coming from the outer portions of the basket, indicating that the external epoxy coating was not generating hydrogen. Nor was cloudiness of water around the external shell of the basket observed, also indicating that no reaction between the epoxy coating and the spent fuel pool water was occurring. This was consistent with the test results documented in the Coatings Qualification Program Report, Section 4.2, which indicated that no significant off gassing or precipitate was observed during the tests.

The coating manufacturer's recommendations specified that the epoxy coating was to be cured for 10 days at ambient temperature prior to being immersed in water. The epoxy coating had been applied to Basket #1 on May 15, 1999. No controls had been established by the licensee to preclude the basket from being placed in the cask loading pit before the 10-day cure time had elapsed. The 10-day cure time requirement had been discussed during a phone call on May 17, 1999, between the licensee and the basket manufacturer. At that time, it was determined to not be a problem based on the schedule. However, on May 22, 1999, the schedule was moved up. This new schedule would have provided an opportunity to place the basket in the cask loading pit prior to the end of the 10-day period.

On May 27, 1999, a management review comment concerning this issue was added to ISFSI Problem Report IPR #156, which had been issued on May 22, 1999, to document the original observation of the rinse water coloration problem during receipt inspection of Basket #1. The management comment specified that the IPR #156 evaluation should also determine how the receipt inspection of Basket #1 was completed when there was still 3 days remaining on the required curing time for the external epoxy coating.

In response to this issue, the licensee added a requirement to the receipt inspection process to verify the 10-day curing period was met.

k. Post Examination of Basket #1

On July 23, 1999, the now emptied basket #1 was moved from the cask loading pit to the cask wash pit. The licensee initiated Maintenance Request #21241 to examine the basket for degradation and effects of being in the spent fuel pool water. The cask had been immersed for 16 days. The licensee examined the coated and uncoated portions of the basket internals. The intent of the examination was to determine if any detrimental effects had occurred to the coating and whether the uncoated carbon steel had undergone corrosion to the point that the thickness was below acceptable design tolerances. Examination of the cells and cross members included:

- visual exam
- in-situ dry film thickness reading
- ultrasonic thickness testing of the metal
- boroscope examination of the welds

- tape tests to evaluate adhesion of the coating

No unusual conditions or major indications of material failure were found during the visual exam. Heavy rust stains were observed on some horizontal surfaces and thin deposits of rust were observed toward the tops of the cells. The coating appeared to be intact. Pin holes and associated rust blooms were observed on the coating.

The in situ dry film thickness readings indicated the coating thickness to vary from 1 mil to 2.5 mils thickness. The recommended manufacturer specification for thickness was 0.8 to 1.2 mils per coat. Multiple coats may be applied to build up the film. The vendor's procedure for applying the coating specified a dry film thickness, after curing, of 0.8 to 3 mils, with a maximum of 5 mils permitted in localized areas. The thickness of the coating on Casks #2 and #3 were also measured. The coating thicknesses were similar on all three casks and were within manufacturer recommended thicknesses.

The ultrasonic testing included two locations on the retention plate, two on the top cross pieces, and six locations on the cells. All thicknesses were found to be within design tolerances. The cell thicknesses ranged from 0.260 to 0.278 inch. Design thicknesses were 0.25+.03/-.00 inch. Measurements were also taken of Cask #3 and compared to Cask #1. Cask #3 measurements were consistent with the thicknesses found on Cask #1.

The boroscope was used to examine dissimilar metal welds in the neutron trap area. Three neutron traps were examined, two of which had been near cells containing fuel. No unusual indications were seen on any of the areas.

Adhesion tests were conducted by the licensee's metallurgist per American Society for Testing Materials (ASTM) D3359. Tests were conducted on top of the cell dividers and on the cell walls of the internal structures. The adhesion test for the coating failed, in that portions of the coating came off. The metal under the coating was found to be free of rust with no evidence of corrosion.

Adhesion tests were also conducted on Baskets #2 and #3. Basket #2 failed the test, however, it had passed a similar test in June. Basket #2 had undergone an extensive cleaning process with demineralized water. Basket #3 passed the adhesion test. Basket #3 had not been washed or placed in the spent fuel pool. A qualitative knife edge scrape test was conducted on Baskets #2 and #3. The coating was easily removed on both baskets with moderate knife edge pressure. The coating on Basket #2 was softer than the coating on Basket #3.

As a result of the problems with the coating, BNFL Fuel Solutions formed an Event Review Team to investigate and determine the causes for the coating failures associated with the baskets. The licensee also conducted an examination of the failure of the coatings. The licensee committed to present to the NRC the results of the investigations and the planned corrective actions.

1.3 Conclusion

Loading of the first TranStor™ basket has been placed on hold at Trojan until resolution of issues concerning the use of the coating on the carbon steel portions of the basket and approval of the licensee's amendment committed to in it's letter to the NRC dated July 20, 1999. BNFL Fuel Solutions and the licensee have initiated an extensive evaluation of the problem and are developing corrective actions. Issues to be resolved include hydrogen generation, heat transfer requirements for the coating, water clarity during loading and adhesion of the coating to the carbon steel.

Heat transfer (emissivity) calculations for the safety analysis report concerning the coating used on the basket's internal components had used a heat load for the basket of 26 kilowatts (kW). The license for the Trojan ISFSI had been issued for a heat load of 24 kW. Because of the age of the Trojan fuel, the maximum heat load that was determined for the Trojan baskets was 16.5 kW. With the lower heat load of the Trojan fuel, no coating on the basket internals was needed to prevent internal basket temperatures from exceeding design limits. Therefore, from the perspective of emissivity, no coating would be required.

The licensee's calculations of the potential amount of hydrogen generated while borated water was in the basket and observation of the amount of gas generated while the basket was actually in the cask loading pit indicated that acceptable administrative controls could be implemented to maintain hydrogen levels below explosive limits during the welding of the cask lids. The licensee's procedures for welding the basket included provisions for purging the basket with inert gas and monitoring for hydrogen.

The licensee's evaluation of the interaction of the spent fuel pool water with the uncoated carbon steel in the basket and the dissolving of the basket coating in the spent fuel pool water determined there would be no adverse effects on the spent fuel cladding or the spent fuel pool clean-up systems.

The carbon steel portions of three shield lids had been coated, however the coating had only been flash cured. Flash curing did not involve the high temperature curing process required to fix the coating to the carbon steel. The licensee has removed the flash cured coating from the three shield lids and implemented controls to preclude further use of the coating on the shield lids.

No provisions had been made by the licensee to ensure that the coating manufacture's recommended 10-day cure time for the epoxy coating used on the external stainless steel surface of the basket was completed prior to placing the basket into the cask loading pit. This was a different type of coating than the coating applied to the basket internals. Had activities been conducted on schedule for the loading of the first basket, the cure time would have been only 7 days. The licensee corrected this issue by adding to the receipt inspection process a requirement to verify the 10-day curing period prior to using the basket.

Test results and actual observation during the time Basket #1 was in the cask loading pit found that the external coating used on the stainless steel basket shell did not generate hydrogen or contribute to the water clarity problem.

An examination of the basket was performed after removal from the cask loading pit. The basket had been in the borated spent fuel pool water for 16 days. The basket passed the visual examination, coating thickness examination, ultrasonic thickness testing of the metal and boroscope examination of the welds. The basket did not pass the tape test for coating adhesion. Portions of the coating came off during the testing.

2 Design Control of ISFSI Components (60851)

2.1 Inspection Scope

The licensee used the safety evaluation process required by 10 CFR 72.48 and 10 CFR 50.59 to evaluate changes to the programs and equipment for the ISFSI. Several selected safety evaluations completed by the licensee were reviewed.

2.2 Observation and Findings

The licensee had developed procedure TPP 18-1 “10CFR50.59, 10CFR72.48, and other Regulatory Evaluations,” Revision 11 to implement the requirements specified in 10 CFR 72.48 “Changes, Test, and Experiments,” and 10 CFR 50.59 “Changes, Test, and Experiments.” This procedure described the process for implementing the requirements of 10 CFR 72.48 and 10 CFR 50.59 to determine when changes were necessary to the Trojan license and other licensing basis documents. The procedure included a detailed checklist for screening issues to determine if a safety evaluation was necessary. If a safety evaluation was determined to be necessary, the procedure provided the forms for documenting the evaluation.

A licensee may make changes to the ISFSI as long as the changes meet the criteria established in 10 CFR 72.48 “Changes, Test, and Experiments.” Specifically, 10 CFR 72.48(a)(1)(iii) requires NRC Commission approval for any activities that would involve a change to a license condition. The licensee had completed Safety Evaluation 200-1 which evaluated the use of the overpack for permanent storage of a defective basket in lieu of temporary storage. The NRC had reviewed the use of the overpack as a temporary storage system as part of the licensing process for the Trojan ISFSI application. The NRC Safety Evaluation, Section 4.3.2.3 “Basket Overpack,” and Section 5.2.2.1 “Description of Basket Overpack,” identified the overpack as an interim measure to confine a damaged or defective basket and had not considered the overpack for long term storage. The licensee’s Safety Evaluation 200-1 had not correctly determined that, to use the overpack for permanent storage, a change was required to Technical Specifications 3.1.1 and 3.1.2 concerning basket integrity. Technical Specifications 3.1.1 and 3.1.2 had established conditions specific to the basket and had not considered the overpack. Specifically, in accordance with 10 CFR 72.48(c)(2), a license amendment from the NRC was required in this case to update the technical specifications to include leak rate checks and vacuum drying of the overpack, if used permanently. In addition, Technical Specification 4.2.1 required updating to include reference to the overpack for permanent storage and should have established the requirement for helium backfill of the overpack for permanent use. Failure to identify the need for a technical specification change was identified as a violation of 10 CFR 72.48 (72-17/9905-01).

PGE Calculation No.TI-86, Revision 0, which supported the conclusions of Safety Evaluation 200-1, was also reviewed. The intent of this calculation was to analyze whether the overpack could be removed from the concrete cask subsequent to a tip over event. The calculation correctly analyzed that the overpack could be removed from the concrete cask; however, the calculation had not adequately evaluated the structural integrity of the overpack subsequent to a tip over event. Specifically, the methodology used did not demonstrate compliance with the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, 1992 Edition with Addenda through 1994. This conclusion was reached for the following reasons; (1) the overpack consisted of a cylinder portion and two end plates; however, the ring analysis performed by the licensee did not evaluate the discontinuity of the connection between the end plates and the cylinder and (2) no evaluation of the stress intensity level for the ring was performed. The calculation only stated that, “the overpack would be expected to remain elastic except for local plastic flow in the region of impact.” The inspector noted that to show vessel integrity, the stress intensity for every portion of the vessel should be examined and shown to be less than the allowable Service Level D limits.

Trojan ISFSI Technical Specification Section 4.3 “Codes and Standards,” requires the overpack to meet the requirements of ASME Boiler and Pressure Vessel Code, Section III, 1992 Edition with Addenda through 1994. As described above, the methodology of PGE Calculation TI-86, Revision 0, did not demonstrate compliance with Technical Specification 4.3. Therefore, this issue is considered an unresolved item until the licensee demonstrates that the overpack complies with Technical Specification 4.3 (72-17/9905-02).

Safety Evaluation 200-7 was completed by the licensee to evaluate the addition of a storage and instrumentation building inside of the ISFSI. The licensee considered this an administrative change which required an update to Figure 2.1-3 of the safety analysis report to show the building on the ISFSI layout. However, the NRC inspectors determined that the safety evaluation was weak in that, it should have evaluated what effect the building would have on the operation of the ISFSI during normal and accident conditions such as cask movements and weather related events. Subsequent to this inspection, the licensee revised the safety evaluation to address the concerns identified by the NRC inspectors.

Safety Evaluation 0139 evaluated miscellaneous changes to the ISFSI transfer cask and lifting yoke. Subsequent to approving the safety evaluation, the licensee made an additional change to the transfer cask by drilling, tapping and plugging a drain hole into the outer shell of the transfer cask. The licensee had added this design change to the list of modifications approved by the safety evaluation and stated that “this change has no effect on the evaluation conclusions.” The licensee did not address each of the questions of Procedure TPP 18-1, nor provide reference to any additional evaluations to support this statement. The change was approved by two individuals who initialed the list of modifications and the above noted statement. The process described above was not provided for in Procedure TPP 18-1. This issue reflects a weakness in the licensee’s process for performing safety evaluations. Subsequent to this inspection, the licensee revised the safety evaluation to address the concerns identified by the NRC inspectors.

The problems identified during the review of the safety evaluations above and safety evaluation SE99-027 discussed in Section 1.2 of this report indicated a general weakness with the implementation of the safety evaluation program. The criterion in Procedure TPP 18-1 allowed for only one independent safety reviewer to approve a safety evaluation. This increased the likelihood that incorrect conclusions or inadequate analyses would be found to be acceptable. The NRC believes that the weaknesses in the safety evaluation program were key elements that directly lead to the problems that were encountered during the attempt to load the first basket. The licensee committed during the exit to evaluate this issue.

2.3 Conclusion

Several safety evaluations conducted by the licensee to meet the requirements of 10 CFR 72.48 and 10 CFR 50.59 were reviewed. The problems identified during the NRC review of the safety evaluations indicated a general weakness with the implementation of the program.

A review of Safety Evaluation 200-1 determined that the licensee had incorrectly concluded that a change from using the overpack as a temporary container to a permanent container could be made without changing the technical specifications. The failure to identify the need for a change to the technical specifications (i.e., a license condition), was determined to be a violation of 10 CFR 72.48.

The licensee performed a calculation to analyze whether the overpack could be removed from the concrete cask subsequent to a tip over event. The calculation had not adequately demonstrated compliance with the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel code requirements. This issue is considered an unresolved item pending further licensee analysis and review by NRC during a future inspection.

3 Follow-up of Open Items (92701)

3.1 (Closed) IFI 50-344/9905-01: Cracks on the ISFSI Lifting Yoke

The licensee had discovered cracks on the lifting yoke that would be used to lift and move the transfer cask and loaded basket. The licensee initiated corrective action report CAR 99-022 to evaluate the cracks and verify the integrity of the lifting yoke. Root cause analysis determined that both weld cooling and joint restraint contributed to the cracking problem. CAR 99-022 contained the following attachments, which were also reviewed.

Attachment 1: Travelers for the Lifting Yoke/Components
Attachment 2: Modification Requests
Attachment 3: UT, MT and PT Results
Attachment 4: Maps and Pictures of the cracks
Attachment 5: Hardness Test Results
Attachment 6: Welding Procedures, Welders Qualification Matrix and Qualification Records for the welders who were listed on the respective travelers provided by HiTech
Attachment 7: Findings/Conclusions from PGE's Metallurgist
Attachment 8: Miscellaneous Information

The evaluation conducted by the licensee to close CAR 99-022 was thorough and included ultrasonic testing, dye penetrant testing and visual examination of the weld areas. The licensee determined that the effects on the lifting yoke from the cracks would have been minimal. The cracks were ground out to parent metal.

3.2 (Closed) IFI 72-17/9902-03: Modification to Fuel Building ARMs

Two area radiation monitors provided criticality alarms in the fuel building spent fuel handling and storage areas. During the movement of a loaded transfer cask near the area radiation monitors, the radiation levels were expected to exceed the alarm points for area radiation monitor #12. The licensee was planning to disable the alarm locally to prevent this problem during cask movement.

Design change document DPMR 99-005, “Installation of Key Operated Alarm Buzzer Defeat Switch in ARM-12” modified area radiation monitor #12 to install a key switch for the local alarm buzzer on the monitor. Procedure FHP 50-03 “Loading and Placing a Concrete Cask into Storage,” incorporated instructions to position the local and audible alarm bypass switch to “defeat” on area radiation monitor #12 when moving a loaded basket nearby. The instructions also incorporated moving the position switch back to the “normal” setting upon completion of movement of the loaded basket. The area radiation monitor was visually inspected and the key switch indicated the “normal” position. The design changes and the supporting and implementing documentation were found to adequately address the problem associated with the potential for unnecessarily alarming the area radiation monitor during cask movement activities.

4 Exit Meeting

The inspectors presented the inspection results to members of licensee management at an interim exit at the conclusion of the onsite inspection on August 4, 1999. A telephonic exit was conducted on September 28, 1999, with the final results of the inspection. The licensee acknowledged the findings presented. The licensee identified as proprietary any information provided to, or reviewed by, the inspectors related to the trade names of coatings that had been evaluated or selected for use on the TranStor™ Storage System.

ATTACHMENT

PARTIAL LIST OF PERSONS CONTACTED

Licensee

K. Allison, ISFSI Project Manager
A. Bowman, Radiation Protection Supervisor
J. Carter, Metallurgist
S. Day, ISFSI Shift Manager
C. Dieterle, Decommissioning Engineer
L. Dusek, Nuclear Regulatory Affairs Manager
D. Gildow, ISFSI Project Manager
M. Janouski, Engineer
T. Meek, Radiation Protection Manager
S. Schneider, Operations Manager
C. Storms, ISFSI Specialist
G. Zimmerman, Licensing Engineer
J. Vesik, Fire Protection Engineer
J. Ulmer, Engineer

State of Oregon

A. Bless, Resident Inspector, Oregon Office of Energy

Contractor

T. McNulty, Engineer, BNFL Fuel Solutions

INSPECTION PROCEDURES USED

60851	Design Control of ISFSI Components
60855	Operations of an ISFSI

ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

72-17/9905-01	VIO	Use of Overpack for Permanent Storage of Spent Fuel
72-17/9905-02	URI	Overpack Compliance with ASME Code

Closed

50-344/9905-01	IFI	Cracks in ISFSI Lifting Yoke
72-17/9902-03	IFI	Modification to Fuel Building Area Radiation Monitors

Discussed

None

LIST OF ACRONYMS

ASTM	American Society for Testing of Materials
ARM	Area Radiation Monitors
CFR	Code of Federal Regulations
FHP	Fuel Handling Procedure
ISFSI	Independent Spent Fuel Storage Installation
NTU	Nephelometric Turbidity Units
PGE	Portland General Electric Company
ppm	parts per million
PWR	Pressurized Water Reactor
SAR	Safety Analysis Report
SNM	Special Nuclear Material
T. S.	Technical Specification